

CLAIMS

What is claimed is:

1. A method for calibrating an electromagnetic navigation system having a transmitter coil array that generates an electromagnetic field, said method comprising:

(a) positioning the electromagnetic navigation system in a working environment to account for metallic distortion caused by a metallic object adjacent to the electromagnetic field;

(b) positioning a calibration sensor at a first calibration point;

(c) energizing a first coil in the transmitter coil array to generate a first field;

(d) sensing a first field strength of the first field with the calibration sensor; and

(e) repeating steps (b), (c) and (d) at a second calibration point, wherein effects of metallic distortion caused by the metallic object is taken into account during the calibration process and wherein the metallic object is a medical device.

2. The method as defined in Claim 1 further comprising energizing a plurality of coils sequentially in the transmitter coil array to generate a plurality of fields and sensing field strengths of each of the plurality of fields with the calibration sensor.

3. The method as defined in Claim 1 further comprising repeating step (e) to generate about eight thousand calibration points.

4. The method as defined in Claim 1 wherein positioning the calibration sensor at a first calibration point further comprises utilizing a robotic unit to position the calibration sensor at the first calibration point.

5. The method as defined in Claim 1 wherein the medical device is selected from a group consisting of operating room table, fluoroscope, microscope, ultrasound hand piece, high-intensity focused ultrasound systems, computer topography imaging (CT), interoperative computer topography, magnetic resonance imaging (MR), interoperative magnetic resonance and surgical robot.

6. The method as defined in Claim 5 wherein at least one of function and movement of the medical device is simulated during the calibration process.

7. The method as defined in Claim 1 further comprising navigating a probe through the electromagnetic field by using the stored field strengths sensed by the calibration sensor.

8. The method as defined in Claim 7 further comprising comparing the stored field strengths sensed by the calibration sensor with field strengths measured by the probe.

9. The method as defined in Claim 8 further comprising using the stored field strengths sensed by the calibration sensor to interpolate fields at a guess point in space.

10. The method as defined in Claim 9 further comprising computing the difference in field strengths between the guess point with the field strength measured by the probe.

11. The method as defined in Claim 10 further comprising using the measured difference to refine the guess point during a minimization process to select a new guess point that is closer to the probe location.

12. The method as defined in Claim 11 further comprising minimizing the error between the guess point and the actual location of the probe to an acceptable value.

13. The method as defined in Claim 1 further comprising creating a look-up table for a plurality of calibration points which is operable to be used during navigation process, where the look-up table stores field strengths for the plurality of calibration points that take into affect the metallic distortion caused by the metallic object adjacent to the electromagnetic field.

14. The method as defined in Claim 1 further comprising energizing the plurality of coils in the transmitter coil array in at least one of a time division multiplex manner, frequency division multiplex manner, or a combination of both.

15. The method as defined in Claim 7 wherein navigating the probe includes navigating a probe selected from at least one of a surgical probe, catheter, steerable catheter, endoscope, shunt, drill guide, awl/tap, orthopedic instrument and a combination thereof.

16. The method as defined in Claim 7 further comprising providing a dynamic reference arc that is affixed relative to a patient and used as a reference point for the probe.

17. A method for navigating an instrument in an electromagnetic navigation system having a transmitter coil array that generates an electromagnetic field, said method comprising:

- (a) referencing a look-up table of calibration field strengths that account for metallic distortion caused by a metallic object adjacent to the electromagnetic field;
- (b) selecting a guess point where the instrument is located;
- (c) energizing the transmitter coil array to generate the electromagnetic field adjacent to the metallic object;
- (d) sensing the electromagnetic field with the instrument;
- (e) interpolating the field strength at the guess point using the look-up table;
- (f) calculating the difference in field strengths between the guess point and the field sensed by the instrument; and
- (e) refining the guess point.

18. The method as defined in Claim 17 wherein selecting the guess point includes selecting an arbitrary start guess point.

19. The method as defined in Claim 17 further comprising energizing the plurality of coils in the transmitter coil array in at least one of a time division multiplex manner, frequency division multiplex manner, or a combination of both.

20. The method as defined in Claim 17 wherein interpolating the field at the guess point includes using at least one interpolation method selected from linear interpolation, spline interpolation, and polynomial curve fitting.

21. The method as defined in Claim 17 wherein refining the guess point includes performing a minimization process to select a new guess point that is closer to the actual instrument location.

22. The method as defined in Claim 21 further comprising minimizing the error between the guess point and the actual instrument location to an acceptable value.

23. The method as defined in Claim 17, wherein the metallic object is selected from a group consisting of operating room table, fluoroscope, microscope, ultrasound hand piece, high-intensity focused ultrasound systems, computer topography imaging (CT), interoperative computer topography, magnetic resonance imaging (MR), interoperative magnetic resonance and surgical robot.

24. The method as defined in Claim 17 wherein navigating the probe includes navigating a probe selected from at least one of a surgical probe, catheter, stroke catheter, endoscope, shunt, drill guide, awl/tap, orthopedic instrument and a combination thereof.

25. The method as defined in Claim 17 wherein the transmitter coil array is controlled via a wireless channel.

26. The method as defined in Claim 17 wherein the instrument senses the electromagnetic field and operates via a wireless channel.

27. An electromagnetic navigation system for use in navigating an instrument through an electromagnetic field positioned near a metal object, said electromagnetic navigation system comprising:

(a) a transmitter coil array having a plurality of transmitter coils, said transmitter coil array operable to generate the electromagnetic field to navigate the instrument; and

(b) a shield positioned adjacent the metal object, said shield operable to substantially shield the metal object from the electromagnetic field generated by said transmitter coil array, said transmitter coil array being attached to said shield, wherein shield substantially reduces distortion of the electromagnetic field by the metal object, thereby enabling accurate navigation of the instrument in the electromagnetic field.

28. The electromagnetic navigation system as defined in Claim 27 wherein said transmitter coil array is integrally formed transmitting coils positioned about a perimeter of said shield.

29. The electromagnetic navigation system as defined in Claim 27 wherein said transmitter coil array is displaced from said shield.

30. The electromagnetic navigation system as defined in Claim 29, wherein said transmitter coil array includes at least three sets of transmitter coils which are displaced from said shield.

31. The electromagnetic navigation system as defined in Claim 30 wherein said three sets of transmitter coils are displaced from said shield by an extension member.

32. The electromagnetic navigation system as defined in Claim 30, wherein each set of transmitter coils includes three sets of coils positioned orthogonal to one another.

33. The electromagnetic navigation system as defined in Claim 27 wherein said transmitter coil array is driven in at least one of a time division multiplexed manner, a frequency division multiplexed manner or a combination of both.

34. The electromagnetic navigation system as defined in Claim 27 wherein the metal object is a fluoroscope.

35. The electromagnetic navigation system as defined in Claim 34 wherein said fluoroscope is a C-arm fluoroscope.

36. The electromagnetic navigation system as defined in Claim 27 wherein at least one of said shield and transmitter coil array is removably attached to said metal object.

37. The electromagnetic navigation system as defined in Claim 34 wherein said shield is integral with said fluoroscope.

38. The electromagnetic navigation system as defined in Claim 27 wherein said instrument includes at least one electromagnetic sensor attached at a distal end of said instrument.

39. The electromagnetic navigation system as defined in Claim 38 wherein the instrument is non-rigid and may bend during navigation and the instrument includes a plurality of electromagnetic sensors to provide further location information regarding the instrument.

40. The electromagnetic navigation system as defined in Claim 27 wherein said transmitter coil array is controlled over a wireless channel.

41. The electromagnetic navigation system as defined in Claim 27 wherein said instrument operates over a wireless channel.

42. The electromagnetic navigation system as defined in Claim 27 wherein the field strength of each coil in the transmitter coil array is stored on a memory medium where each field strengths takes into account interference from the metal object.

43. The electromagnetic navigation system as defined in Claim 42 wherein the memory medium is a flash ROM.

44. An electromagnetic navigation system for use in navigating an instrument through an electromagnetic field positioned near a fluoroscope, said electromagnetic navigation system comprising:

(a) a transmitter coil array having a plurality of transmitter coils, said transmitter coils array operable to generate the electromagnetic field to navigate the instrument; and

(b) a shield attached to the fluoroscope, said shield operable to substantially shield the fluoroscope from the electromagnetic field generated by said transmitter coil array, wherein said shield substantially reduces distortion of the electromagnetic field by the fluoroscope, thereby enabling accurate navigation of the instrument in the electromagnetic field.

45. The electromagnetic navigation system as defined in Claim 44 wherein at least one of said transmitter coil array is integrally formed transmitting coils positioned about a perimeter of said shield.

46. The electromagnetic navigation system as defined in Claim 44 wherein said transmitter coil array is displaced from said shield.

47. The electromagnetic navigation system as defined in Claim 46 wherein said transmitter coil array includes at least three sets of transmitter coils which are displaced from said shield.

48. The electromagnetic navigation system as defined in Claim 47 wherein said three sets of transmitter coils are displaced from said shield by an extension member.

49. The electromagnetic navigation system as defined in Claim 44 wherein each set of transmitter coils includes three sets of coils positioned orthogonal to one another.

50. The electromagnetic navigation system as defined in Claim 44 wherein said transmitter coil array is driven in at least one of a time division multiplexed manner, frequency division multiplexed manner or a combination of both.